Chapter 14

Anatomical and Biomechanical Context

In the preceding chapters, morphology was introduced and a myriad of named features of individual bones were detailed as a means of identifying isolated and/or fragmentary skeletal remains. Some of the relationships that these features have with the "soft" anatomical structures attached to the bones in the once-living individual were considered. Here we continue that exploration, offering visualizations of the relationships among bones and the soft tissues that link them during life. The forces that these "soft" tissues (such as muscles and ligaments) exert can influence the overall shapes of the bones as well as their surface morphology.

The "soft" anatomical structures illustrated in this chapter were included when they met certain criteria: 1) the anatomical structure directly attaches to the illustrated bone or its periosteum; 2) at least one of the attachment sites of the anatomical structure is visible on at least one view of the bone; 3) the anatomical structure exerts a tensile force on the bone (*i.e.,* it is not a blood vessel, nerve, fat deposit, bursa, etc.). Periosteum is not illustrated because it is ubiquitous. Because of space constraints, some cranial ligaments and all of the intrinsic muscles of the eye and ear are not illustrated. Note that the soft tissue attachment maps are only inferred approximations of what the actual original soft tissue attachments were during life.

Because of space limitations, only selected elements are illustrated in this chapter. The six major long bones of the upper and lower limbs were included, as was the clavicle. Each of these long bones is distinguished by possessing both a complex surface topography and a complex cross-sectional architecture. In addition, the skull and the os coxae were included due to the complexity and number of soft tissue attachments on each.

14.1 Anatomical Conventions

Skeletal muscles act to produce movement of the body. Muscles and their tendons often extend across joints. When the muscle contracts, it exerts a tensile force that causes the bones to move relative to one another, using the joint between them as a fulcrum.

In general, muscles have a fleshy belly that sits between two tendinous (or sometimes fleshy) ends. The **origin** of a muscle is the end attached to the more stable or inertial side of a joint (usually the side closest to the body's axis). A muscle's **insertion** is the end attached to the more movable side of a joint. For example, the *biceps brachii* spans both the shoulder (glenohumeral) joint and the elbow (cubital) joint. When the *biceps brachii* contracts, as when doing a dumbbell curl,

the elbow joint is flexed. Because of the relative mass of the forearm versus the rest of the body, it is the forearm that moves the most. Thus, anatomists call the radial end of the *biceps brachii* the insertion, and the humeral and scapular ends are called the origins. In anatomical illustrations, sites of muscular origins are traditionally colored red, and sites of muscular insertions are blue. Articular surfaces are shown in yellow on the figures in this chapter. These conventions have been followed in the figures in this chapter.

Ligaments are cords, bands, or sheets of tough, fibrous tissue that, like muscles, typically cross joints and have attachment sites on bones. Unlike muscles, ligaments are entirely passive. Instead of contracting to produce movement at a joint (like muscles), ligaments typically remain slack until the bones of a joint are closer to being dislocated. Ligaments resist tension, thereby strengthening the joint and permitting only movements compatible with the function of the joint.

The anatomical terminology used in this chapter is in accordance with the latest international standards for such terminology, as expressed in the *Terminologia Anatomica* (FCAT, 1998). Because adoption of the new terminology standard has been uneven in North America (Martin et al., 2009, 2010; Vogl, 2009), synonymous older terminology is also presented where it may prove helpful.

14.2 Biomechanical Conventions

The long bones in this chapter (clavicle, humerus, radius, ulna, femur, tibia, fibula) were micro-CT scanned at the five standard sections: 20%, 35%, 50%, 65%, and 80% of biomechanical length. By convention, section locations are measured from the *distal* end of the long bone (*i.e.,* the distalmost of these sections is called the 20% section). These micro-CT scans were taken from the same bones used to illustrate Chapters 4–13. Details of the scanning methodology can be found in Appendix 1.

In addition to the rich visual information CT scans provide concerning the internal morphology of a bone, they are a valuable source of data that can be used to calculate approximations of a bone's mechanical properties. The total amount of bone (in cross section), the distribution of that bone around the central axis of the bone, the microstructure of the bone, and the material properties of the bone all contribute to these mechanical properties.

Biomechanists model long bones as beams in order to better understand their mechanical properties. The **bending strength** (*i.e.,* rigidity, or resistance to bending) of a beam is the product of two quantities: E (**Young's modulus**), and I (the **second moment of area**, usually called the "**moment of inertia**"). Young's modulus, E, describes how a material responds (usually in terms of how much it changes in length) when stressed by a force applied over a given area of that material. It is convention to assume that variation in Young's modulus is negligible within hominids (Jungers and Minns, 1979; Lovejoy and Barton, 1980; Ruff, 1992; Ruff et al., 1993), an assumption supported by the discovery that the material properties of bone have been conserved over the last 475 million years (Erickson et al., 2002). With Young's modulus held constant, the second moment of area can be used alone as an accurate indicator of the relative bending strength of a bone.

The moment of inertia of a beam is a description of the distribution of material around the neutral axis of the beam (the longitudinal axis that is neither compressed nor stretched when the beam is bent). Since the exact location of the neutral axis cannot be determined on dry bone specimens, the location of the neutral axis in any dry bone cross section is conventionally assumed to coincide with the centroid of the cross section.

With the help of calculus and specialized image analysis software, all bone in the cross section can be broken into infinitesimally small portions. The area of these infinitesimally small portions can be determined mathematically, and the distance of each of these areas from an arbitrary line passing through the neutral axis can be determined. The summation of the products of these areas and their squared distances yields the moment of inertia with respect to the arbitrary line. If these calculations are done for every orientation of the arbitrary line (from 0° to 180°), the greatest sum will represent I_{max}, which is effectively a measure of the bone's greatest resistance to

bending. ***Theta*** (θ) indicates the orientation of the greatest resistance to bending. I_{min}, which is always perpendicular to I_{max}, is the bone's lowest bending resistance. The sum of I_{max} and I_{min} is J, the **polar moment of inertia**, a measure of the bone's resistance to twisting (or axial torsion).

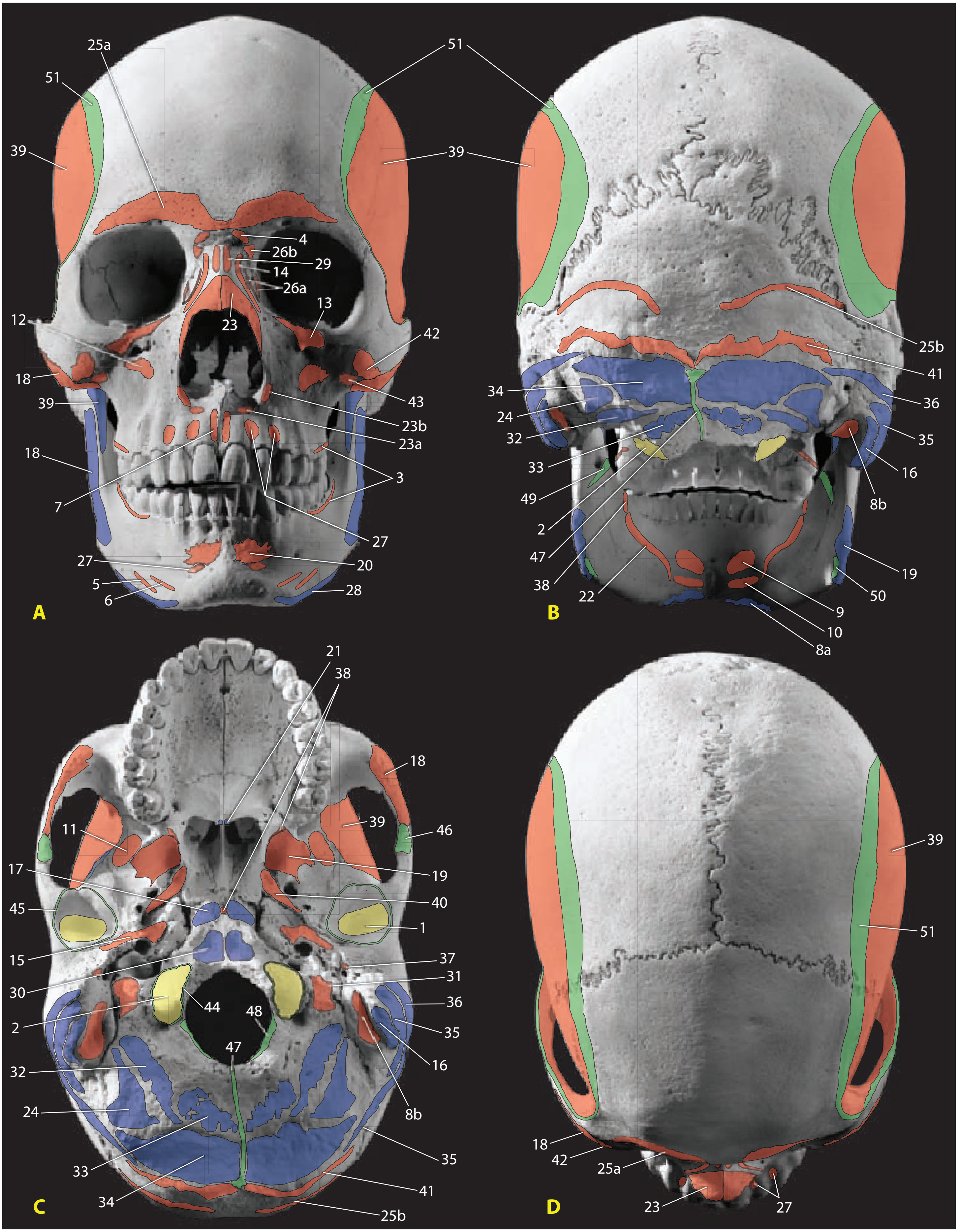
Newton's **Third Law of Motion** states that for every action, there is an equal but opposite reaction. The Third Law applies to living systems as well as inanimate objects. In walking and running, propulsion of the body is produced by contracting muscles of the lower limb. Plantarflexor muscles, originating on the posterior side of the lower leg and attaching to the calcaneus via the Achilles tendon, contract at the same time as the quadriceps, the primary extensor of the lower leg. The coordinated action of these two muscle groups straightens the leg and plantarflexes the foot at the ankle, producing a strong force that is delivered backwards to the ground through the toes. As predicted by Newton's Third Law, this "action" force is met by an equal but opposite **ground reaction force**, and forward motion results. The same type of interaction of forces continues upwards through the body, with the talus exerting a force on the tibia (and being met by a reaction force), the tibia exerting a force on the femur (and being met by a reaction force), and so on. These reaction forces across joints are called **joint reaction forces**.

For joints that experience high (or repetitive) joint reaction forces (*e.g.,* the knee), the articular ends are expanded, providing additional area across which the forces are distributed. These articular ends are thin-shelled structures, maintaining their strength and rigidity through a complex network of reinforcing rods and plates — the trabeculae of cancellous bone. Consult the longitudinal section shown in Figure 3.6 to see the relationship between trabeculae and an expanded articular end of a bone with high joint reaction forces.

14.3 Interpreting the Figures

For the elements on the following pages, the locations of all muscular, tendinous, and ligamentous attachments, and of all articulations with other elements are given specifically for the same individual whose postcrania were used to illustrate Chapters 3 – 13. The hand and foot are not presented for reasons of space, but students are encouraged to use these conventions and imagine how soft tissue attachments would map onto Figures 10.2–10.3 and 13.2–13.5 for the hand and foot (and Figure 6.1 for the hyoid, Figures 8.6–8.9 for the scapula, Figure 7.1 for the sternum, Figures 7.3–7.5 for the ribs, Figures 6.2–6.3 and 6.7 for the vertebrae, Figures 11.1–11.4 and 11.6 for the sacrum and coccyx, and Figure 12.9 for the patella). When there is sufficient surface evidence of original extent, the soft tissue attachments are rendered as accurately as possible. In many cases, however, at least part of the extent of an attachment had to be estimated.

For each soft anatomical structure illustrated, numerous anatomical atlases (Abrahams et al., 2007; Agur and Dalley, 2008; Clemente, 2010; Dauber and Feineis, 2007; Gilroy et al., 2008; Netter, 2006, 2010; Rohen et al., 2006, 2010; Schünke et al., 2006) were consulted to ascertain the range of attachment locations and sizes considered typical and/or anatomically normal. This range of typical locations and extents was then reconciled with the specific landmarks, morphology, and surface characteristics of the particular element being illustrated. This work was done on high-resolution digital images of the element, usually at magnifications of 600% to 4000% of natural size, to be able to precisely locate the boundaries of each attachment site. The attachment sites illustrated in this chapter are not necessarily typical or even anatomically normal. They correspond to the specific anatomy of this one individual. For illustrations of typical anatomy, refer to any of the modern anatomical atlases listed in the Suggested Further Readings at the end of this chapter.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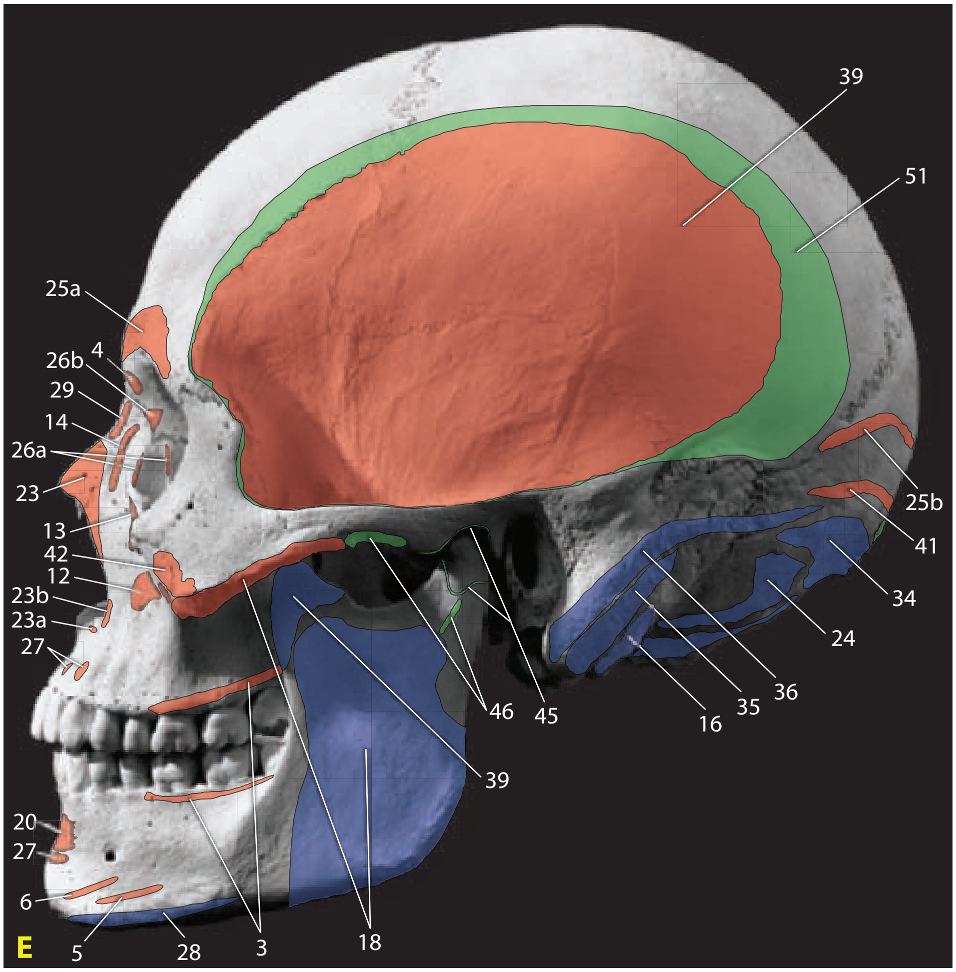


14.4 Cranium and Mandible

Views shown: A) anterior/ norma frontalis, B) posterior/ norma occipitalis, C) inferior/ norma basilaris, D) superior/ norma verticalis, and E) lateral/ norma lateralis, presented at 80% of natural size. Due to space constraints, many cranial ligaments are not shown. Additionally, attachments of the muscles of the eye and of the ear, and some of the muscles of the styloid process are not shown.

Articular surfaces (yellow)

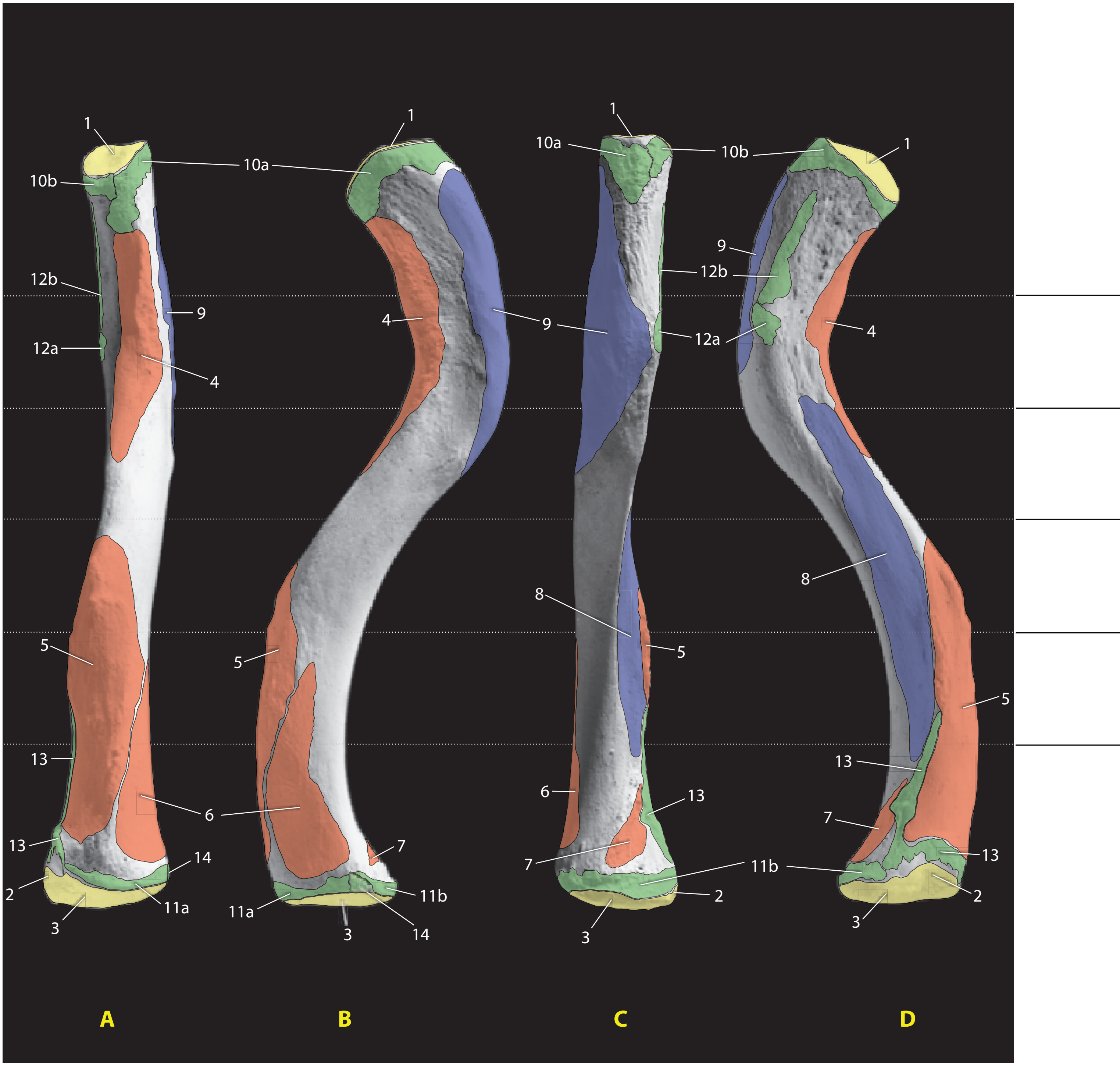
1. Glenoid fossa (for mandible)
2. Occipital condyle (for C-1)

Muscular attachments (origins: red, insertions: blue)

3. Buccinator
4. Corrugator supercilii
5. Depressor anguli oris
6. Depressor labii inferioris
7. Depressor septi nasi
8. Digastric
    a. Anterior belly
    b. Posterior belly
9. Genioglossus
10. Geniohyoid
11. Lateral pterygoideus
12. Levator anguli oris
13. Levator labii superioris
14. Levator labii superioris alaeque nasi
15. Levator veli palatini
16. Longissimus capitis
17. Longus capitis
18. Masseter
19. Medial pterygoideus
20. Mentalis
21. Musculus uvulae
22. Mylohyoid
23. Nasalis
    a. Alar part
    b. Transverse part
24. Obliquus capitis superior
25. Occipitofrontalis
    a. frontal belly (frontalis)
    b. occipital belly (occipitalis)
26. Orbicularis oculi
    a. lacrimal parts
    b. orbital part
27. Orbicularis oris
28. Platysma
29. Procerus
30. Rectus capitis anterior
31. Rectus capitis lateralis
32. Rectus capitis posterior major
33. Rectus capitis posterior minor
34. Semispinalis capitis
35. Splenius capitis
36. Sternocleidomastoideus
37. Stylopharyngeus
38. Superior pharyngeal constrictor
39. Temporalis
40. Tensor veli palatini
41. Trapezius
42. Zygomaticus major
43. Zygomaticus minor

Other attachments (green)

44. Joint capsule (atlanto-occipital joint)
45. Joint capsule (temporomandibular joint)
46. Lateral ligament
47. Nuchal ligament
48. Posterior atlanto-occipital membrane
49. Sphenomandibular ligament
50. Stylomandibular ligament
51. Temporal fascia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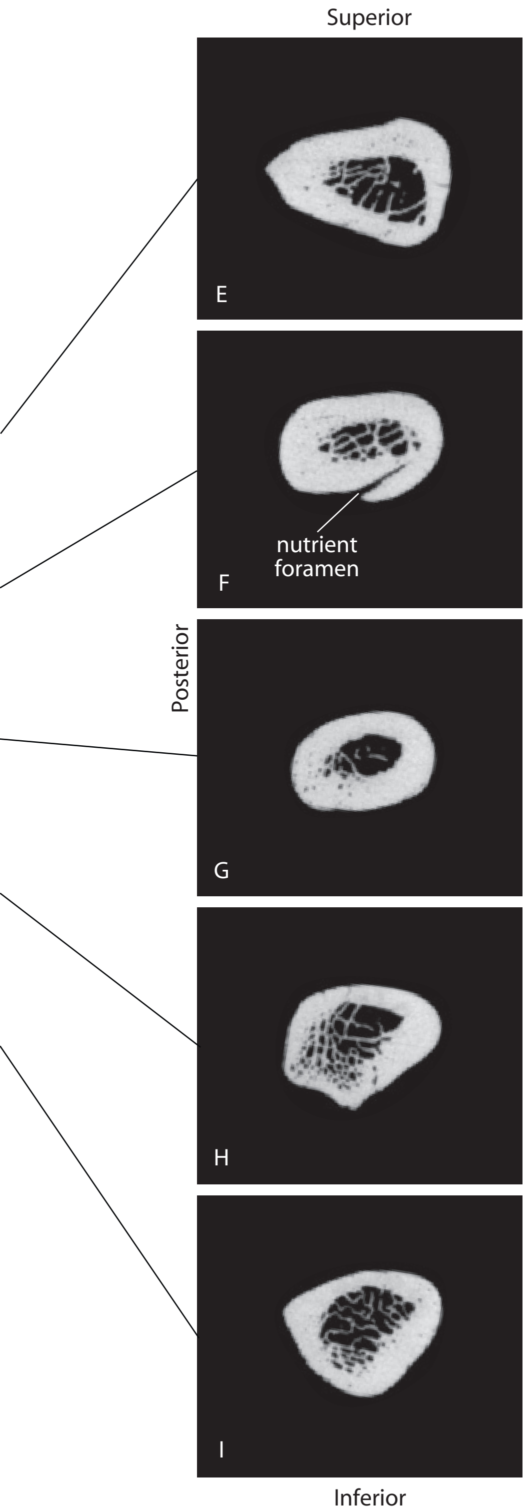


14.5 Clavicle

Views shown: A) anterior, B) superior, C) posterior, and D) inferior, presented at natural size. The CT sections are shown at approximately 1.25× natural size.

Articular surfaces (yellow)

1. Acromioclavicular articulation
2. First costal cartilage
3. Manubrioclavicular articulation

Muscular origins (red)

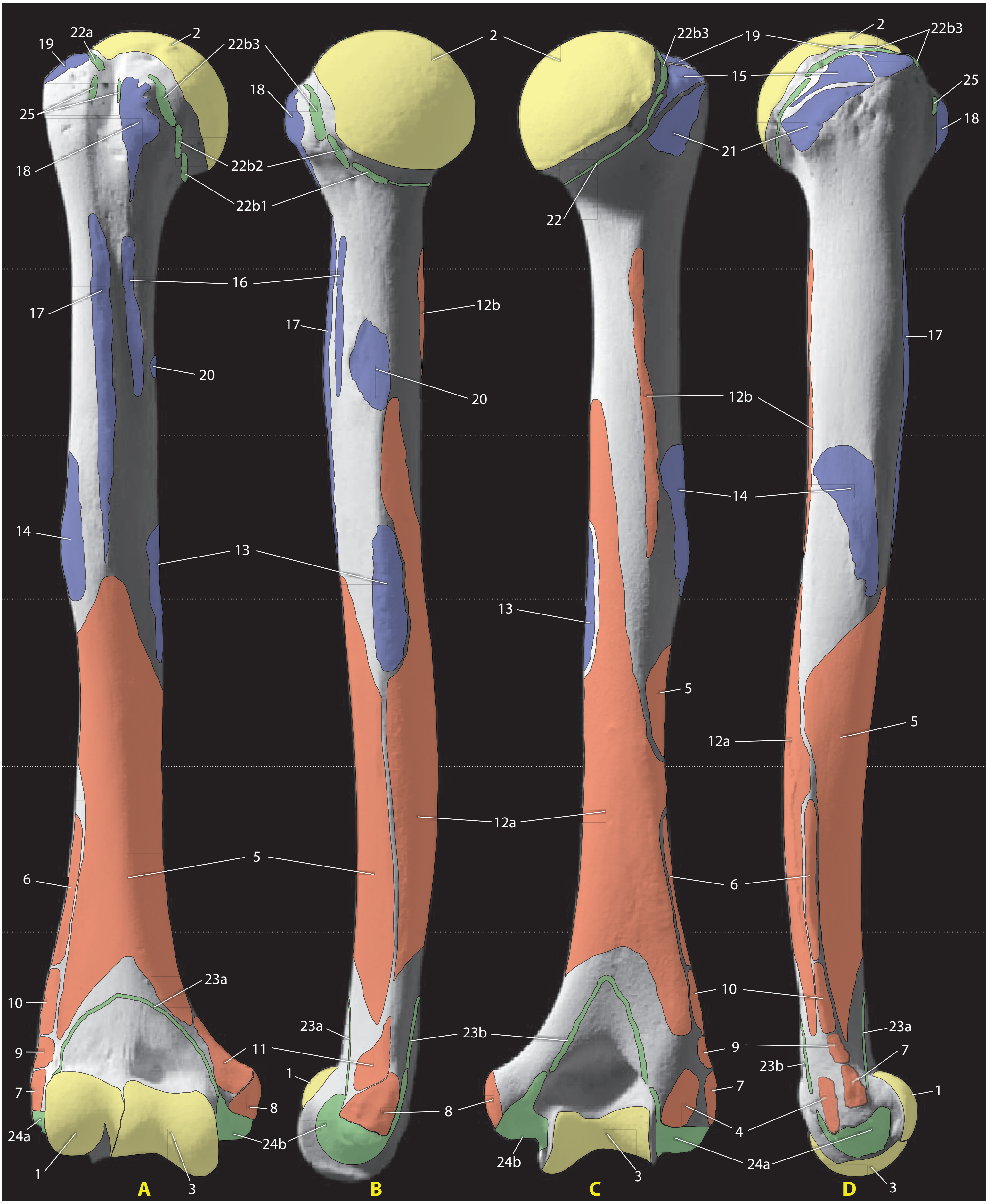
4. Deltoideus
5. Pectoralis major
6. Sternocleidomastoideus
7. Sternohyoid

Muscular insertions (blue)

8. Subclavius
9. Trapezius

Other attachments (green)

10. Capsular ligaments (acromioclavicular joint)
    a. Superior acromioclavicular ligament
    b. Inferior acromioclavicular ligament
11. Capsular ligaments (sternoclavicular joint)
    a. Anterior sternoclavicular ligament
    b. Posterior sternoclavicular ligament
12. Coracoclavicular ligament
    a. Conoid ligament
    b. Trapezoid ligament
13. Costoclavicular (rhomboid) ligament
14. Interclavicular ligament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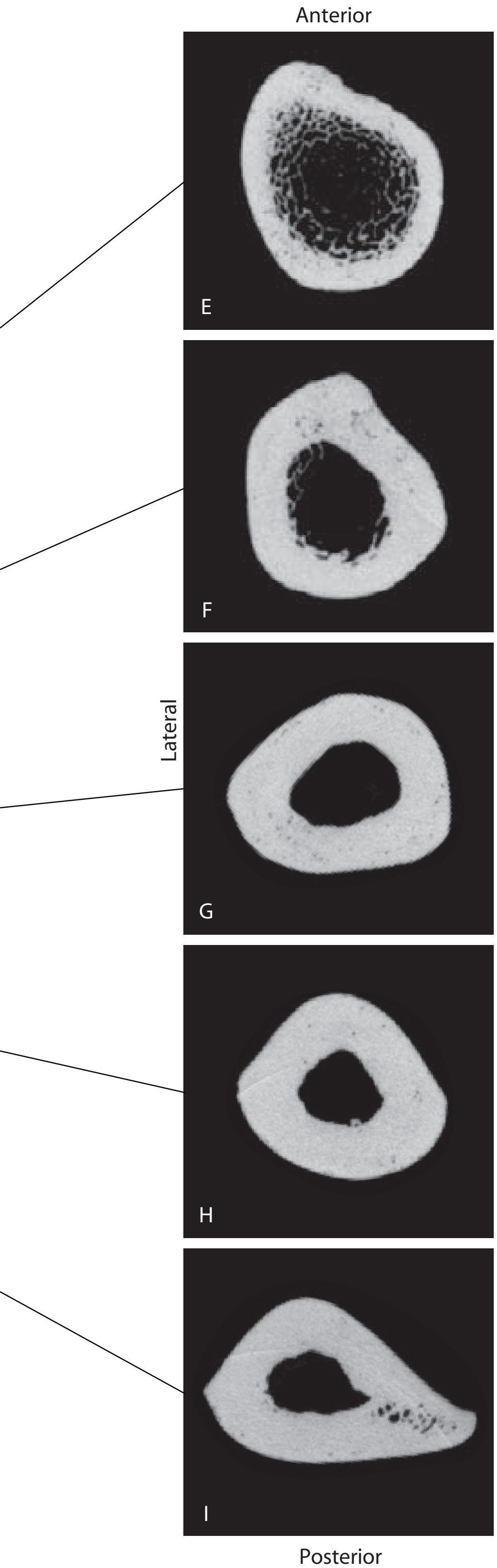


14.6 Humerus

Views shown: A) anterior, B) medial, C) posterior, and D) lateral, presented at 80% of natural size. The CT sections are shown at approximately 1.25× natural size.

Articular surfaces (yellow)

1. Capitulum (for radial head)
2. Head (for scapular glenoid fossa)
3. Trochlea (for ulnar semilunar notch)

Muscular origins (red)

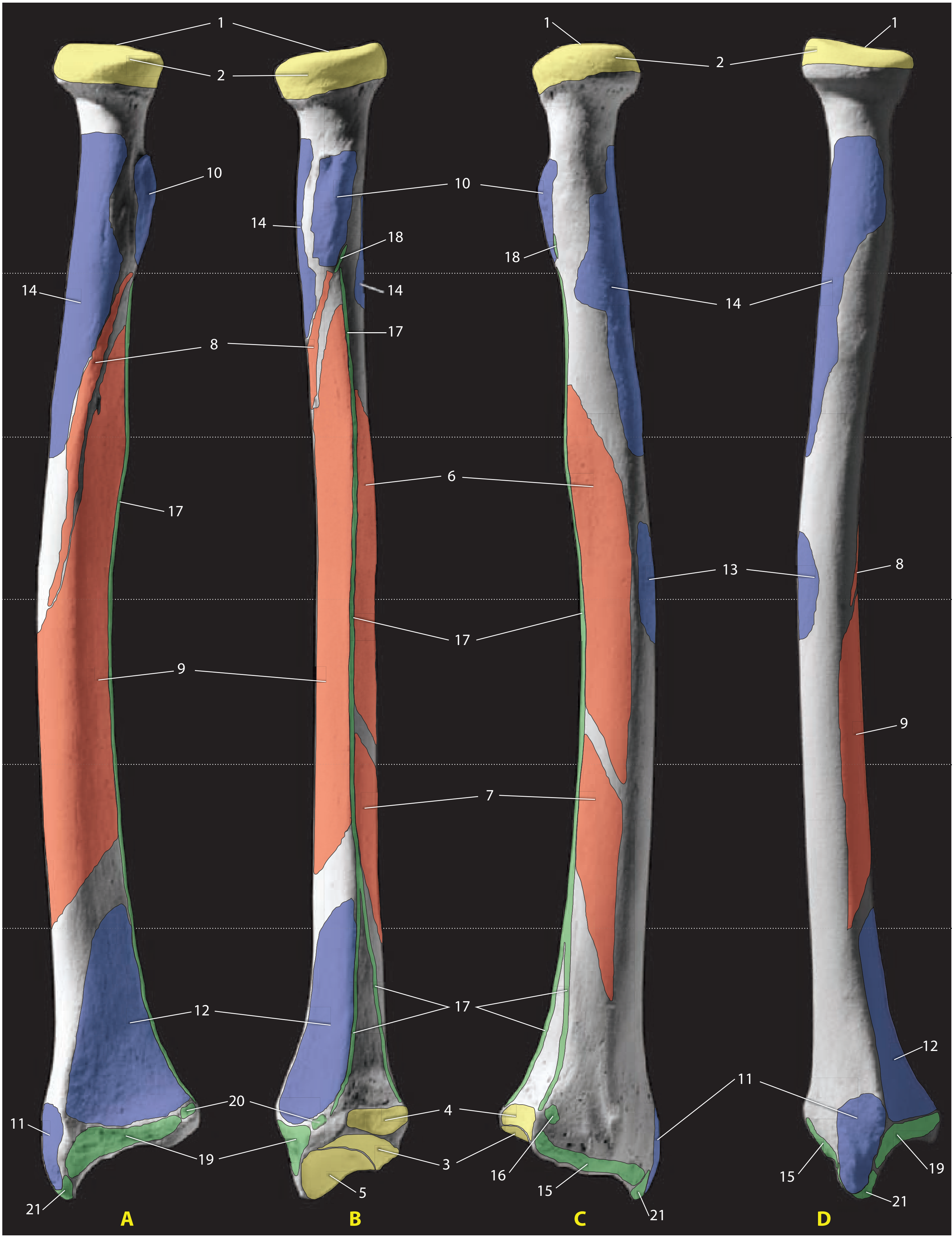
4. Anconeus
5. Brachialis
6. Brachioradialis
7. Common origin of extensors
8. Common origin of flexors
9. Extensor carpi radialis brevis
10. Extensor carpi radialis longus
11. Pronator teres
12. Triceps brachii
    a. medial head
    b. lateral head

Muscular insertions (blue)

13. Coracobrachialis
14. Deltoideus
15. Infraspinatus
16. Latissimus dorsi
17. Pectoralis major
18. Subscapularis
19. Supraspinatus
20. Teres major
21. Teres minor

Other attachments (green)

22. Capsular ligaments (shoulder)
    a. Coracohumeral ligament
    b. Glenohumeral ligaments
        b1. inferior glenohumeral lig.
        b2. middle glenohumeral lig.
        b3. superior glenohumeral lig.
23. Capsular ligaments (elbow)
    a. anterior
    b. posterior
24. Collateral ligaments
    a. Radial (lateral) collateral ligament
    b. Ulnar (medial) collateral ligament
25. Transverse humeral ligament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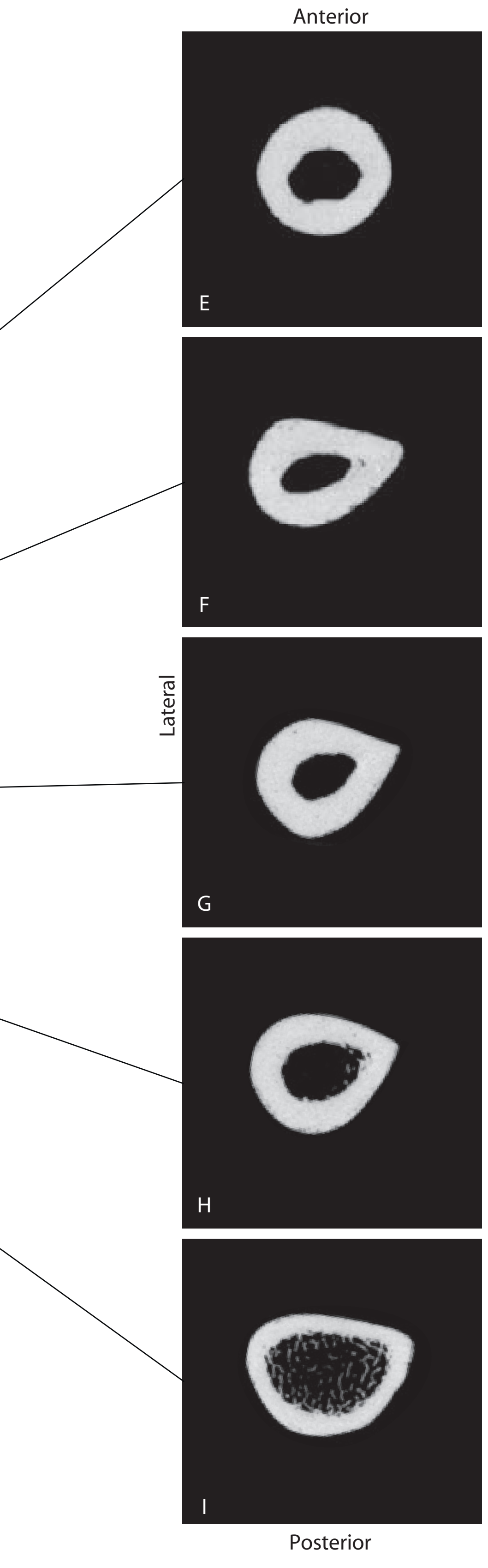


14.7 Radius

Views shown: A) anterior, B) medial, C) posterior, and D) lateral, presented at 90% of natural size. The CT sections are shown at approximately 1.25× natural size.

Articular surfaces (yellow)

1. Articular fovea (for humerus)
2. Articular circumference (for ulna)
3. Lunate facet (for lunate)
4. Ulnar notch (for ulna)
5. Scaphoid facet (for scaphoid)

Muscular origins (red)

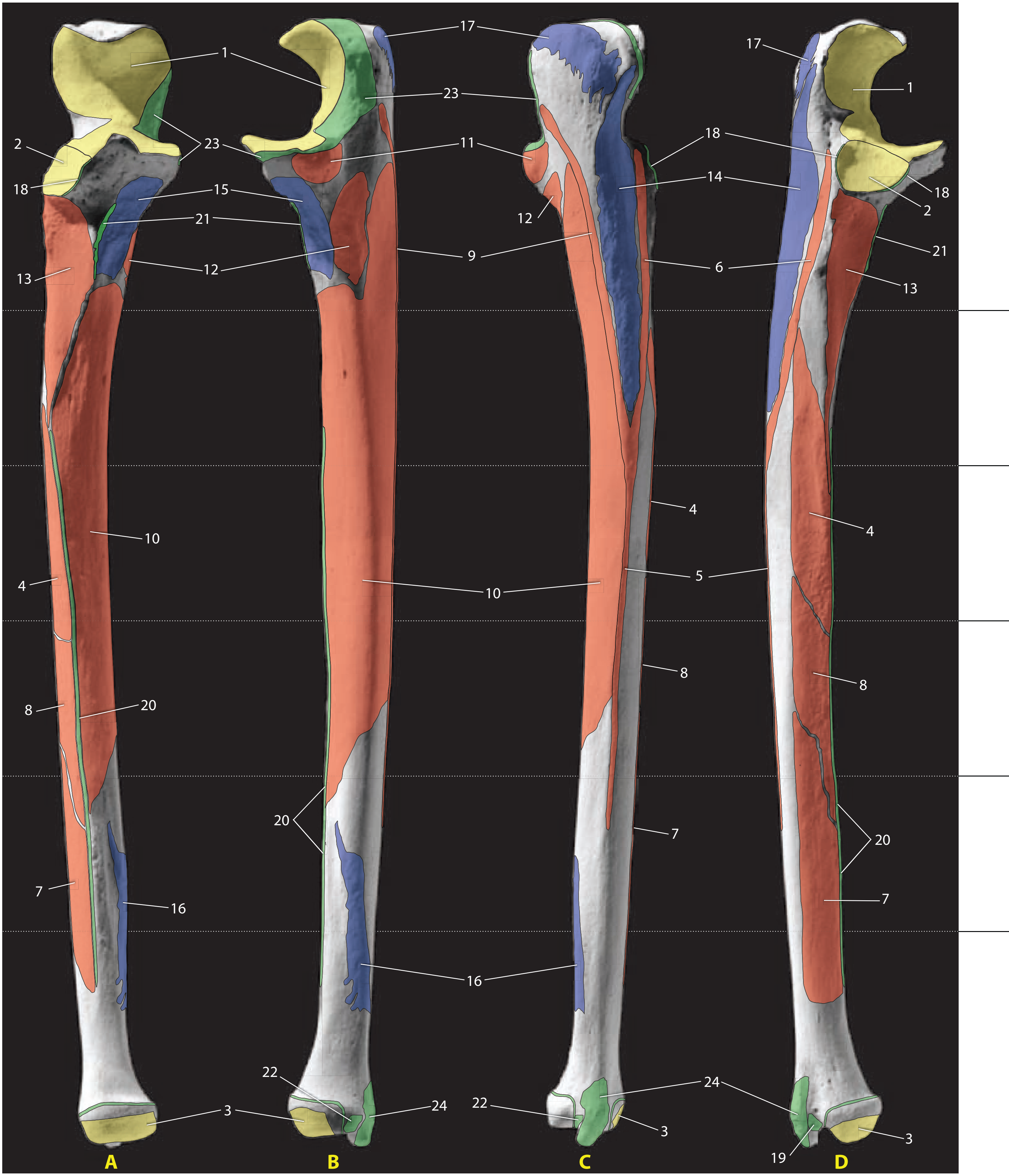
6. Abductor pollicis longus
7. Extensor pollicis brevis
8. Flexor digitorum superficialis
9. Flexor pollicis longus

Muscular insertions (blue)

10. Biceps brachii
11. Brachioradialis
12. Pronator quadratus
13. Pronator teres
14. Supinator

Other attachments (green)

15. Dorsal radiocarpal ligament
16. Dorsal radioulnar ligament
17. Interosseous membrane
18. Oblique cord
19. Palmar radiocarpal ligament
20. Palmar radioulnar ligament
21. Radial collateral ligament



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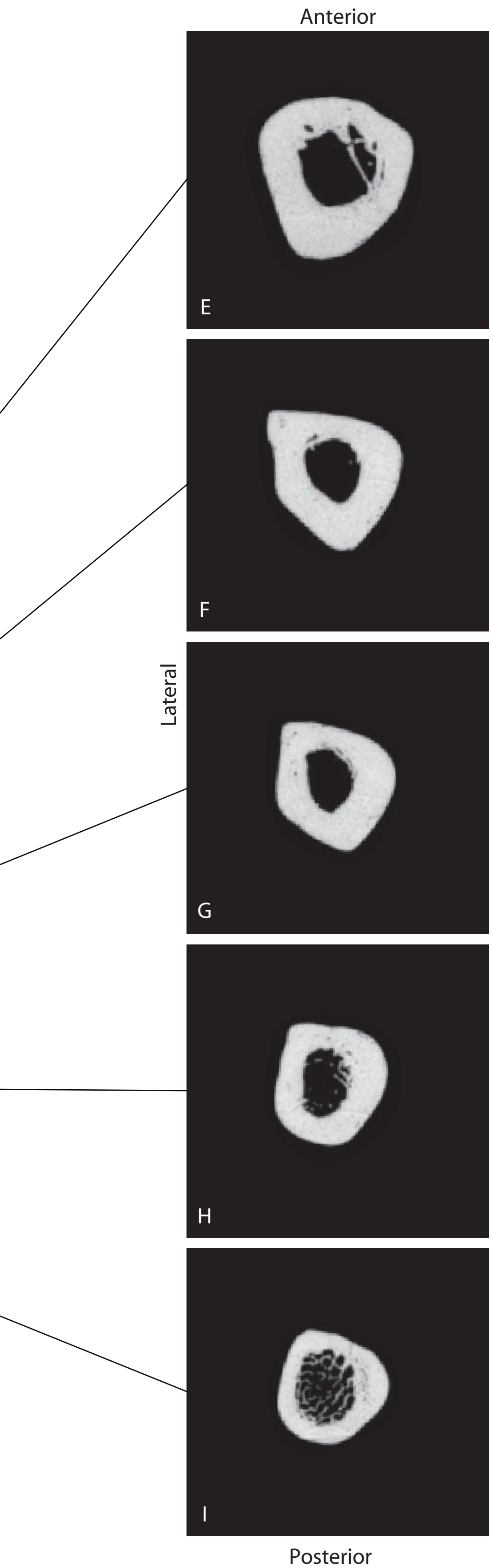


14.8 Ulna

Views shown: A) anterior, B) medial, C) posterior, and D) lateral, presented at 85% of natural size. The CT sections are shown at approximately 1.25× natural size.

Articular surfaces (yellow)

1. Trochlear surface (for humerus)
2. Radial notch (for radius)
3. Articular circumference (for radius)

Muscular origins (red)

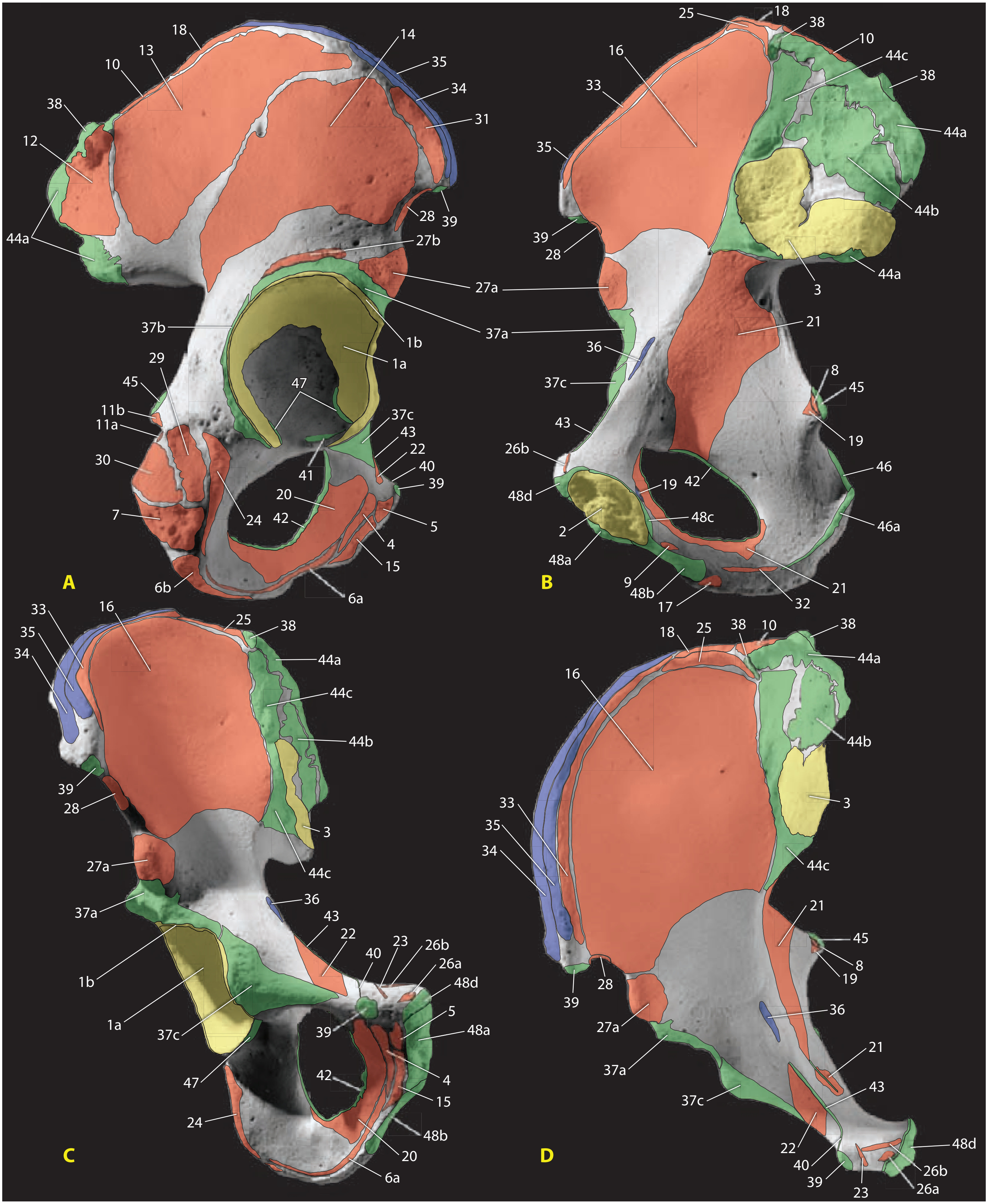
4. Abductor pollicis longus
5. Common origin (aponeurosis) of flexor digitorum profundus, flexor carpi ulnaris, and extensor carpi ulnaris
6. Extensor carpi ulnaris
7. Extensor indicis
8. Extensor pollicis longus
9. Flexor carpi ulnaris
10. Flexor digitorum profundus
11. Flexor digitorum superficialis
12. Pronator teres (ulnar head)
13. Supinator

Muscular insertions (blue)

14. Anconeus
15. Brachialis
16. Pronator quadratus
17. Triceps brachii

Other attachments (green)

18. Anular ligament
19. Dorsal radioulnar ligament
20. Interosseous membrane
21. Oblique cord
22. Palmar radioulnar ligament
23. Ulnar (medial) collateral lig. (prox.)
24. Ulnar (medial) collateral lig. (dist.)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14.9 Os Coxae

Views shown: A) lateral, B) medial, C) anteroinferior, and D) anterosuperior, presented at 60% of natural size.

Articular surfaces (yellow)

1. Acetabulum (for femur)
    a. Lunate surface
    b. Acetabular labrum
2. Pubic symphysis (for os coxae)
3. Auricular surface (for sacrum)

Muscular origins (red)

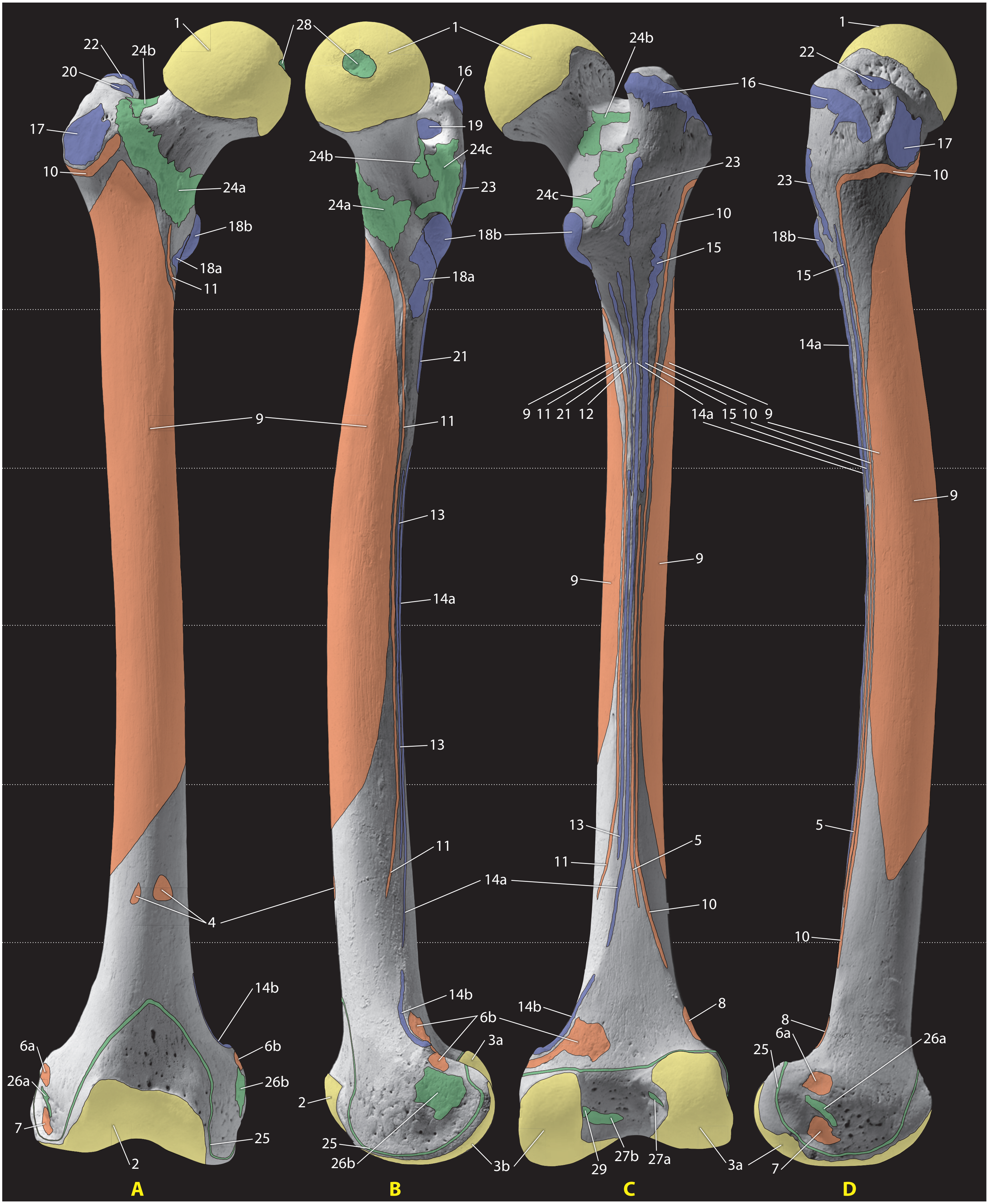
4. Adductor brevis
5. Adductor longus
6. Adductor magnus
    a. Adductor portion
    b. Hamstring portion
7. Biceps femoris (long head)
8. Coccygeus
9. Compressor urethrae
10. Erector spinae
11. Gemelli
    a. Gamellus inferior
    b. Gamellus superior
12. Gluteus maximus
13. Gluteus medius
14. Gluteus minimus
15. Gracilis
16. Iliacus
17. Ischiocavernosus
18. Latissimus dorsi
19. Levator ani
20. Obturator externus
21. Obturator internus
22. Pectineus
23. Pyramidalis
24. Quadratus femoris
25. Quadratus lumborum
26. Rectus abdominis
    a. Medial head
    b. Lateral head
27. Rectus femoris
    a. Straight head
    b. Reflected head
28. Sartorius
29. Semimembranosus
30. Semitendinosus
31. Tensor fascia latae
32. Transverse perinei
33. Transversus abdominis

Muscular insertions (blue)

34. External oblique
35. Internal oblique
36. Psoas minor

Other attachments (green)

37. Capsular ligaments (hip)
    a. Iliofemoral ligament
    b. Ischiofemoral ligament
    c. Pubofemoral ligament
38. Iliolumbar ligament
39. Inguinal ligament
40. Lacunar ligament
41. Ligamentum teres
42. Obturator membrane
43. Pectineal ligament
44. Sacroiliac ligaments
    a. Dorsal sacroiliac ligament
    b. Interosseous sacroiliac ligament
    c. Ventral sacroiliac ligament
45. Sacrospinous ligament
46. Sacrotuberous ligament
    a. Falciform process of ligament
47. Transverse acetabular ligament
48. Symphyseal ligaments
    a. Anterior symphyseal ligament
    b. Inferior (arcuate) pubic ligament
    c. Posterior symphyseal ligament
    d. Superior pubic ligament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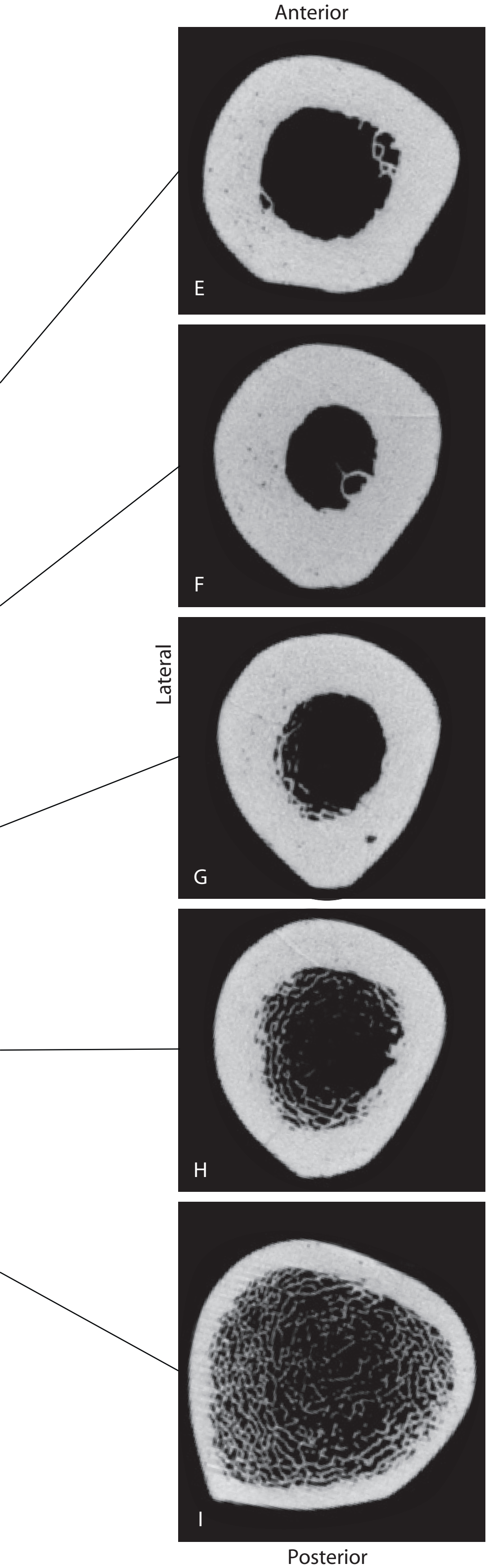


14.10 Femur

Views shown: A) anterior, B) medial, C) posterior, and D) lateral, presented at 40% of natural size. The CT sections are shown at approximately 1.25× natural size.

Articular surfaces (yellow)

1. Head (for os coxae)
2. Patellar surfaces (for patella)
3. Femoral condyles (for tibia)
   Lateral condyle
   Medial condyle

Muscular origins (red)

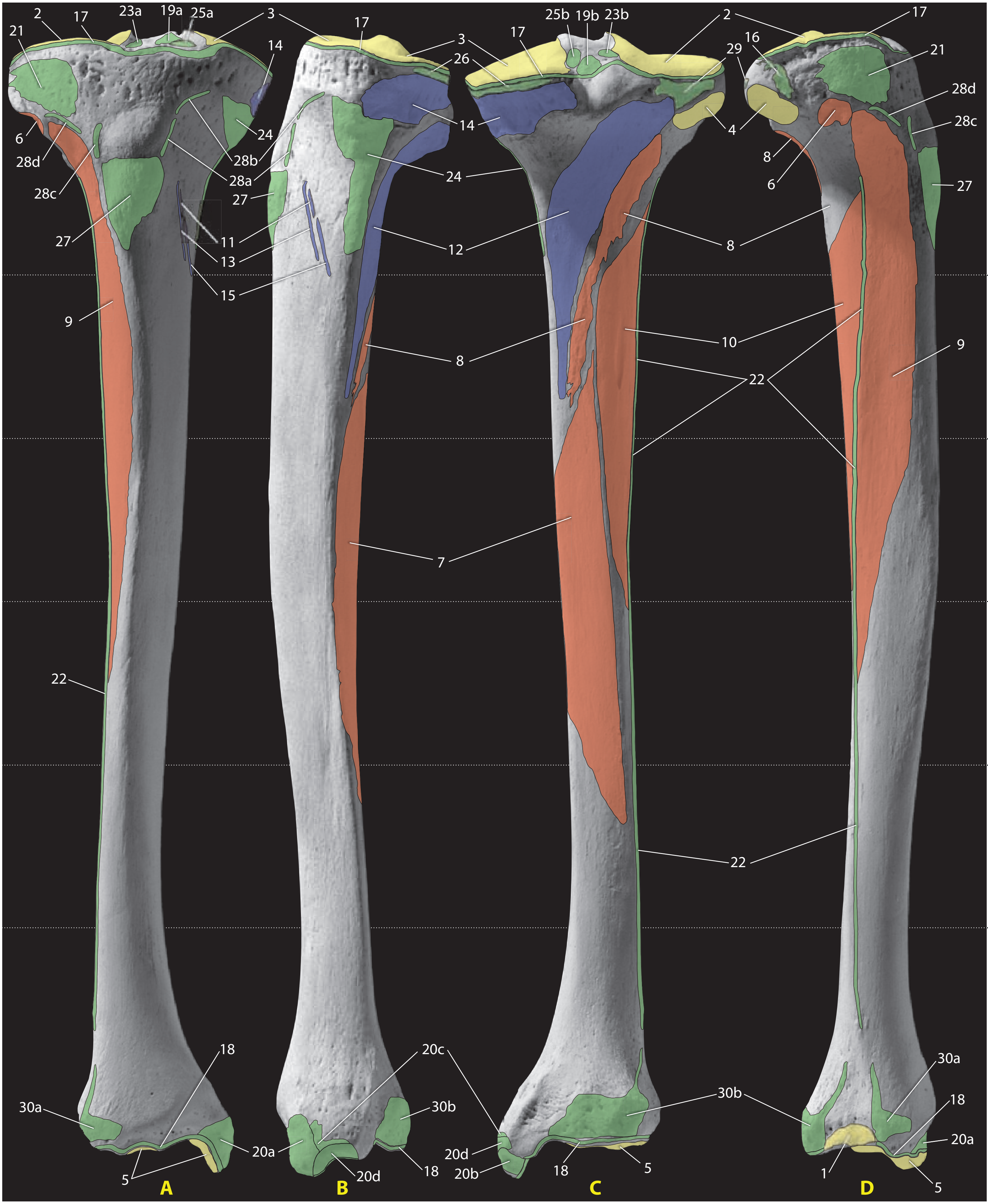
4. Articularis genu
5. Gastrocnemius
   a. Lateral head
   b. Medial head
6. Plantaris
7. Vastus intermedius
8. Vastus lateralis
9. Vastus medialis

Muscular insertions (blue)

10. Adductor brevis
11. Adductor longus
12. Adductor magnus
    a. Adductor portion
    b. Hamstring portion
13. Biceps femoris
14. Gluteus maximus
15. Gluteus medius
16. Gluteus minimus
17. Iliopsoas
    a. Iliacus
    b. Psoas major
18. Obturator externus
19. Obturator internus and gemelli
20. Pectineus
21. Piriformis
22. Popliteus
23. Quadratus femoris

Other attachments (green)

24. Capsular ligaments (hip)
    a. Iliofemoral ligament
    b. Ischiofemoral ligament
    c. Pubofemoral ligament
25. Capsular ligaments (knee)
26. Collateral ligaments
    a. Fibular (lateral) collateral ligament
    b. Tibial (medial) collateral ligament
27. Cruciate ligaments
    a. Anterior cruciate ligament
    b. Posterior cruciate ligament
28. Ligamentum teres
29. Posterior meniscofemoral ligament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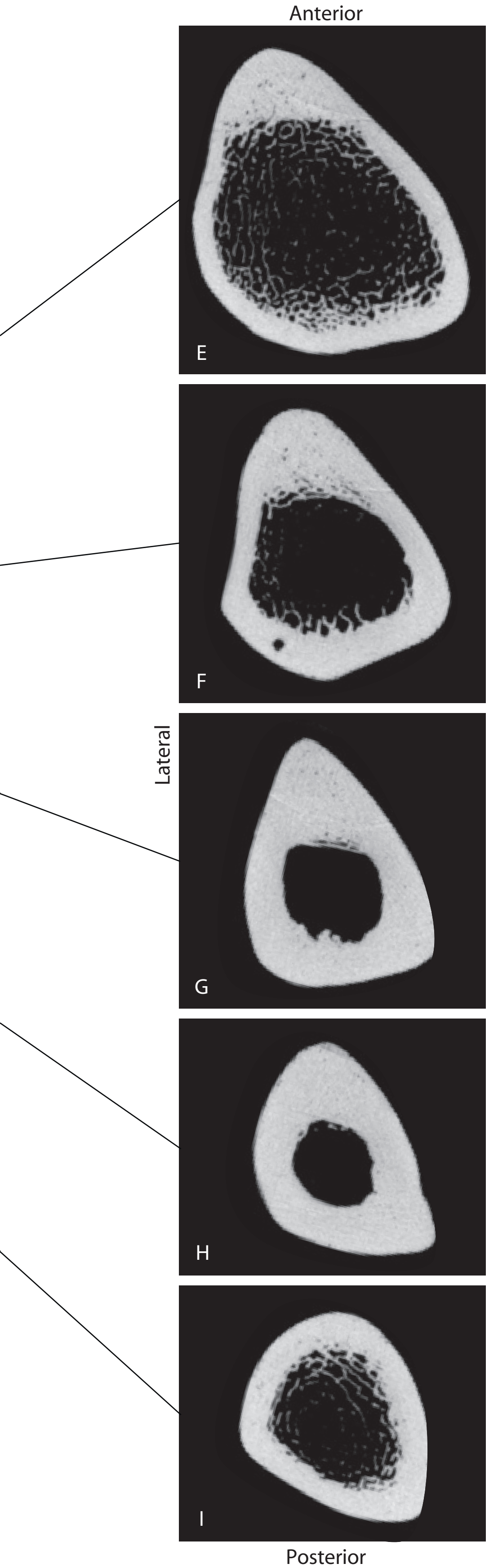


14.11 Tibia

Views shown: A) anterior, B) medial, C) posterior, and D) lateral, presented at approximately 80% of natural size. The CT sections are shown at approximately 1.25× natural size.

Articular surfaces (yellow)

1. Distal fibular artic. surface (for fibula)
2. Lateral condyle (for femur)
3. Medial condyle (for femur)
4. Superior articular facet (for fibula)
5. Talar articular surface (for talus)

Muscular origins (red)

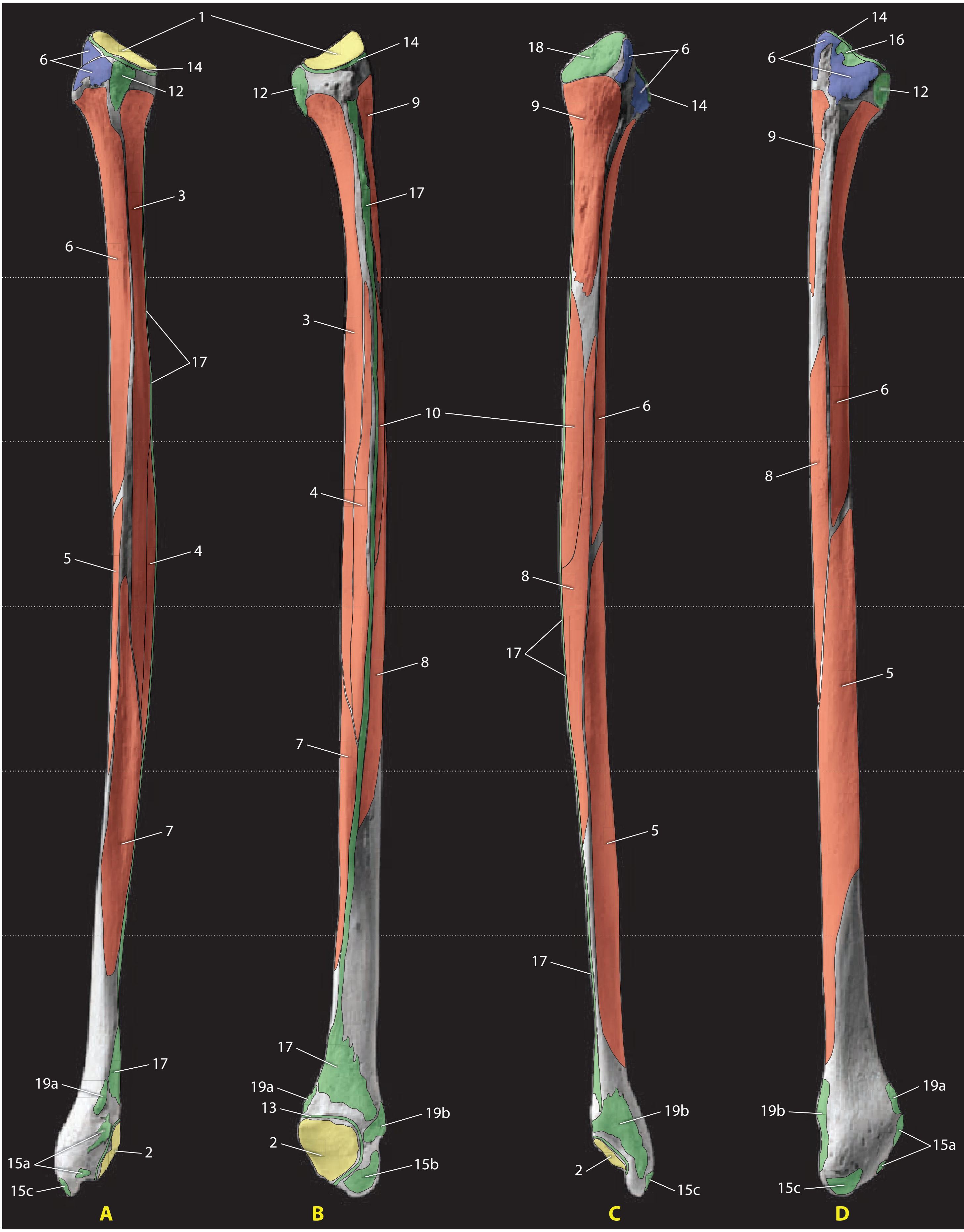
6. Extensor digitorum longus
7. Flexor digitorum longus
8. Soleus
9. Tibialis anterior
10. Tibialis posterior

Muscular insertions (blue)

11. Gracilis
12. Popliteus
13. Sartorius
14. Semimembranosus
15. Semitendinosus

Other attachments (green)

16. Anterior ligament of fibular head
17. Capsular ligaments (knee)
18. Capsular ligaments (ankle)
19. Cruciate ligaments
    a. Anterior cruciate ligament
    b. Posterior cruciate ligament
20. Deltoid ligament
    a. Anterior tibiotalar part
    b. Posterior tibiotalar part
    c. Tibiocalcaneal part
    d. Tibionavicular part
21. Iliotibial tract
22. Interosseous membrane
23. Lateral meniscus
    a. Anterior attachment
    b. Posterior attachment
24. Medial (tibial) collateral ligament
25. Medial meniscus
    a. Anterior attachment
    b. Posterior attachment
26. Oblique popliteal ligament
27. Patellar ligament
28. Patellar retinacula
    a. Medial longitudinal patellar retinaculum
    b. Medial transverse patellar retinaculum
    c. Lateral longitudinal patellar retinaculum
    d. Lateral transverse patellar retinaculum
29. Posterior ligament of fibular head
30. Syndesmotic ligaments of ankle
    a. Anterior tibiofibular ligament
    b. Posterior tibiofibular ligament



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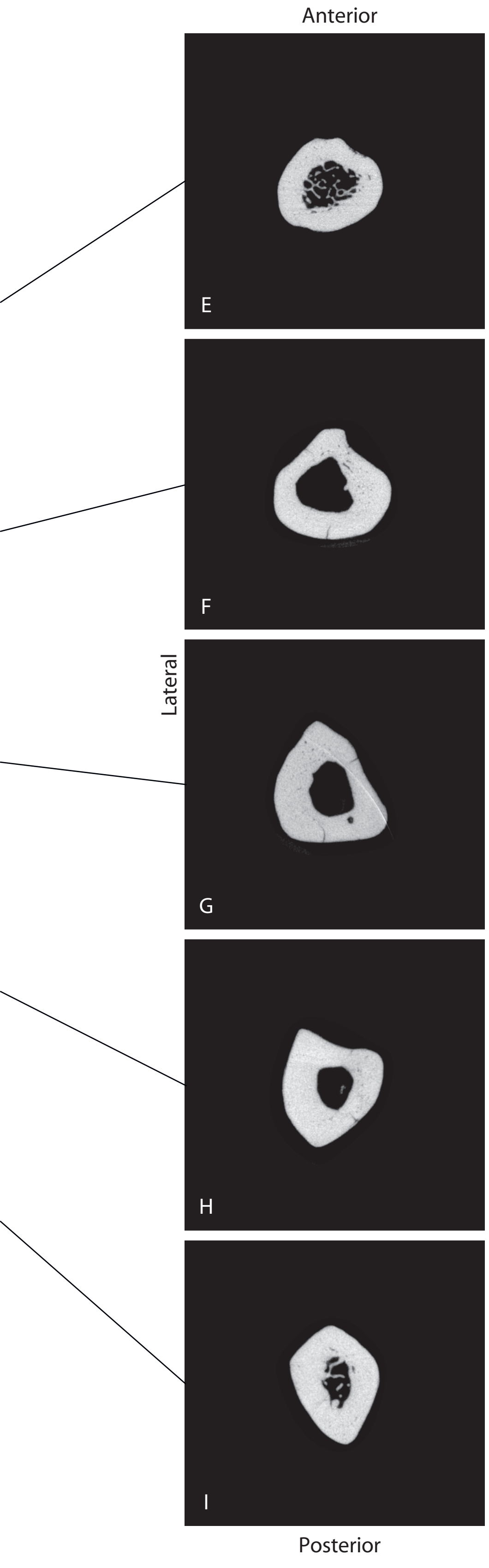

14.12 Fibula

Views shown: A) anterior, B) medial, C) posterior, and D) lateral, presented at 50% of natural size. The CT sections are shown at approximately 1.25× natural size.

Articular surfaces (yellow)

1. Head (for tibia)
2. Malleolar artic. surface (for talus)

Muscular origins (red)

3. Extensor digitorum longus
4. Extensor hallucis longus
5. Fibularis (peroneus) brevis
6. Fibularis (peroneus) longus
7. Fibularis (peroneus) tertius
8. Flexor hallucis longus
9. Soleus
10. Tibialis posterior

Muscular insertions (blue)

11. Biceps femoris

Other attachments (green)

12. Anterior ligament of head of fibula
13. Capsular ligaments (ankle)
14. Capsular ligaments (knee)
15. Fibular (lateral) collateral ligaments (ankle)
    a. Anterior talofibular ligament
    b. Posterior talofibular ligament
    c. Calcaneofibular ligament
16. Fibular (lateral) collateral ligament (knee)
17. Interosseous membrane
18. Posterior ligament of head of fibula
19. Syndesmotic ligaments of ankle
    a. Anterior tibiofibular ligament
    b. Posterior tibiofibular ligament

Suggested Further Readings

Many guides to musculoskeletal anatomy are available. Some of the best of these are listed here.

Abrahams, P. H., Boon, J. M., Spratt, J. D., Hutchings, R. T., and McMinn, R. M. H. (2007) *McMinn's clinical atlas of human anatomy* (6th ed.). St. Louis, MO: Mosby/Elsevier. 386 pp. + DVD.

An atlas based on color photographs of careful cadaveric dissections.

Agur, A. M. R., and Dalley, A. F. (2008) *Grant's atlas of anatomy* (12th ed.). Philadelphia, PA: Lippincott Williams & Wilkins. 834 pp.

A classic medical school atlas to accompany dissection. Uses full-color drawings and schematic illustrations.

Clemente, C. D. (2010) *Anatomy: A regional atlas of the human body* (6th ed.). Baltimore, MD: Lippincott Williams & Williams. 752 pp.

An atlas based on color illustrations. Not a comprehensive atlas, but valued for its clarity and clinical orientation.

Dauber, W., and Feneis, H. (2007) *Pocket atlas of human anatomy, founded by Heinz Feneis* (5th ed.). New York, NY: Thieme. 545 pp.

A comprehensive pocket reference to anatomical terminology. Each two-page spread has one page of shaded line drawings with numeric labels and a one-page key to the labeled structures. Terminology is aligned with the latest international standards.

Federative Committee on Anatomical Terminology. (1998) *Terminologia Anatomica: International anatomical terminology*. New York, NY: Thieme. 292 pp + CD-ROM.

The latest international standard for anatomical terminology.

Gilroy, A. M., MacPherson, B. R., and Ross, L. M. (2008) *Atlas of anatomy*. New York, NY: Thieme. 656 pp.

A comprehensive reference atlas with highly detailed, full-color illustrations, as well as many tables and charts. Its detail, clarity, and coverage make this a must-have atlas. Terminology is aligned with the latest international standards.

Moeller, T., and Reif, E. (2009) *Atlas of sectional anatomy: The musculoskeletal system*. New York, NY: Thieme. 300 pp.

Presents MRI scans alongside colored interpretive diagrams of those sections.

Netter, F. H. (2010) *Atlas of human anatomy* (5th ed.). Philadelphia, PA: Saunders/Elsevier. 624 pp.

A popular medical school atlas using full-color drawings and schematic illustrations, and valued for its ease of use and accessibility.

Putz, R., and Pabst, R. (Eds.) (2009) *Sobotta atlas of anatomy* (14th ed.). Munich, Germany: Urban & Fischer Verlag/Elsevier. 842 pp.

An atlas based on color illustrations and supplemented by radiographs, CT scans, and MRI scans. Terminology is aligned with the latest international standards.

Rohen, J. W., Yokochi, C., and Lütjen-Drecoll, E. (2010) *Color atlas of anatomy: A photographic study of the human body* (7th ed.). Philadelphia, PA: Lippincott Williams & Wilkins. 556 pp.

An atlas based on color photographs of careful cadaveric dissections, supplemented by MRI, CT, and endoscopic images, and by schematic drawings.

Schünke, M., Ross, L. M., Lamperti, E. D., Schulte, E., Schumacher, U., Rude, J., Voll, M., and Wesker, K. (2006) *Thieme atlas of anatomy: General anatomy and musculoskeletal system*. New York, NY: Thieme. 560 pp.

Beautifully illustrated volume focusing on neuromusculoskeletal anatomy.